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ABSTRACT

This paper presents a literature review related to the time spent teaching science and a study designed to test the hypothesis that student achievement in science is related to classroom hours devoted to science instruction. The study involved testing two groups of eighth grade earth science students (N=200) over instructional material presented to one group where the subject is taught for a single semester and to another group where the subject is taught for two consecutive semesters. Both groups were given an identical 75-item multiple choice test covering such topics as plate tectonics, earthquakes, and volcanism. Statistical results (t-test) of this pilot study demonstrate that the group taught for two semesters scored significantly higher than the group taught for a single semester. It is noted that, since the study has not been repeated on other groups in different circumstances, the results should be considered as preliminary. However, should the same test be given over a period of time to many other students, and the results remain significant, then it can be inferred that the amount of material learned is related to the time spent teaching science. (JN)

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Introduction

Throughout the United States there is growing concern about the lack of scientifically trained people to take the places of scientists now engaged in the nation's vital research and to teach science and mathematics to future generations. This problem has been highlighted in the popular press by labeling pre-college students as scientifically illiterate and by pointing out the shortage of qualified science and math teachers. President Reagan has stated that the problems in elementary and secondary science education are serious enough to compromise America's ability to compete in the world marketplace and that this inability will directly harm our standard of living. Colleges throughout the country have simplified their entrance examinations for science and math, and few college freshmen elect to pursue these fields (Lagowski, 1981). Even fewer are pursuing careers that require graduate level science and math courses.

Scientific illiteracy creates problems that extend beyond the obvious symptom of shortage of competent technical professionals. Science, along with math, teaches logical thought processes. When this aspect of learning is ignored, or at best overlooked, the child is ill-equipped to deal with the changes in technology that will confront him in his later years. Research (Butts, 1981) has shown that people with good problem-solving skills score higher on reading comprehension tests than do people with poor problem-solving skills. Science can be thought of as an interdisciplinary course because the skills taught there are used in every classroom in the form of organization and problem-solving techniques. However, today's educational

pattern of teaching as many facts as possible in the shortest amount of time does not utilize the benefits of science education.

It is instructive to examine specific examples at the state and local level. Texas requires only one semester of science per year in grades 6 through 8, and only two semesters in high school. Some school districts allow only one semester in which to teach the complicated eighth grade earth science curriculum. Thus, these districts expose students to a vast amount of material in one semester with the hope that some will catch it like other childhood diseases. Science is not treated in the same manner as math, English, and history, the "basic" subjects. The problem of adequate science education is further magnified because of insufficient money to pay teaching scientists on an equal scale with those in industry. Philosophy and local opinion also play a vital role. When asked why eighth grade science was not being offered as a two-semester course, the Vice-Superintendent of a suburban Dallas school district stated that junior high school students needed electives more than they needed a full year of science. The administrator also stated that not many students were taking science as an elective in high school, and went on to state that amoung sixth graders who failed, the highest percentage failed science (cited in Harrod, 1982). Possibly the failure of sixth grade students can be traced to elementary education. Elementary teachers may not be comfortable with the subject because of their lack of background or they may not have the classroom time to provide a good science foundation (Gerlovich and Downs, 1980).

This paper has two objectives: 1) To review the literature related to the time spent teaching science and 2) to test the specific hypothesis that student achievement in science is related to classroom hours devoted to science instruction. The second objective was carried out by testing two groups of eighth grade earth science students over instructional material presented to one group during a single semester and to the other group in two consecutive semesters.

Problem Definition

By taking away time from the science classroom, students are being deprived of part of their basic education -- they may not learn how to think and solve problems logically. Students need courses which teach or help promote the use of formal and abstract thinking (Lawson, Nordland, and DiVito, 1975). Studies have shown that approximately 75% of secondary school and college level students responding to reasoning (Piagetian) type tests failed to demonstrate formal reasoning abilities (Herron, 1975; Lawson, et al., 1975; Renner and Phillips, 1980). Because students are not trained in formal thought, high school and college teachers are constrained to teach only what the students can superficially memorize. Therefore the students never develop a level of formal operations which permits thinking on an abstract level (Herron, 1975). Knowledge is built on information gained through thinking. The ability to reason and understand comes from being able to relate one thing to another. This skill must be learned (Ebel, 1982).

In the late 1950's there was a push to intensify science

education in part because of the Sputnik crisis. The effect was that science was treated as a basic course from elementary school through high school. Students were given considerable scientific training. This resulted in institutes of higher education raising standards for freshman science programs. Unfortunately, the trend has now been reversed. Colleges and universities have had to lower their standards for science programs because students are less scientifically literate (Lagowski, 1980).

Time for Science?

Science education seems to take a great deal of time, possibly because it takes time to teach logical thought processes. Three years of science should be required in junior high school because science and math are the courses which promote logical and critical thought (Yeotis and Hosticka, 1980). In the sixth grade there is very rapid growth of the brain; however, little growth occurs after the eighth grade (Sklary, 1982). Time spent teaching children between the ages of six and thirteen thinking skills is justified because it is still possible to structure their thinking ability (Boyer and Linn, 1978) and because their thought processes are in transition from the concrete to the formal level (Yeotis and Hosticka, 1980).

Time spent in the classroom has a relationship to the students' achievement. Because on task behavior is positively related to achievement, more learner involved tasks lead to higher achievement (Capie, Dillshaw, and Okey, 1979). It is unclear whether low anxiety levels produce on task behavior or vice versa. It is clear though

that students with more experience in science do better on their achievement tests (Butts, 1981). If this is true, perhaps rushing through a two-semester course in one-semester will have the effect of lowering achievement scores. Scores for 9 to 13 year-olds on the National Assesments of Educational Progress have dropped. The students were tested for their knowledge of science and on their ability to use the ideas of science to solve problems or explain events. A spokesperson for the NAEP stated: "It might be all right to spend less time doing science if students were learning more per unit of time, but that is clearly not the case" (cited in Rowe, 1980). Lengthening the time spent in the science classroom emphasizes the importance of the science curriculum. Emphasis on science produces more students interested in science related fields as well as a broader understanding of science by the general public. Because technology is changing so quickly, science illiteracy prevents the populace from understanding their world and dealing with it in a logical manner (Gerlovich and Downs, 1980; Lagowski, 1980; Yeotis and Hosticka, 1980).

Lack of interest in science is reflected not only by the declining scores on science achievement tests but also by the declining number of scientists (Gerlovich and Downs, 1980; Lagowski, 1981; Rutherford, 1981). Reasons for the decrease in the number of science oriented students are varied. Children learn more readily what they observe than what they are told, and role modeling can provide an effective method of teaching; however, due to low salaries and low

prestige, there are few scientists in the teaching profession. Other reasons for science illiteracy include the lowering of science and math requirements for high school graduation (Lagowski, 1981), the rapid growth of technology, the lack of a science crisis situation, and the time spent on less basic subjects such as homemaking, choir, woodshop, and art (Gerlovich and Downs, 1980). These are minor reasons in light of the fact that science is no longer considered a basic skill (Lagowski, 1980). The "back to basics" movements of the 1970's stressed reading writing, and math but left out science (Lagowski, 1980). Contemporary problems of the last few years have compounded the reasons for reduced science education. Jack Gerlovich and Gary Downs (1980) state that these problems are:

1. lack of planning time
2. lack of "prepared" science teachers
3. lack of time to teach
4. lack of teacher interest
5. the belief that science is a subject of lesser importance

It is not surprising that "science not treated as a basic subject" and "lack of time" are on this list. These are the two basic reasons that science is being omitted from elementary school (Rowe, 1980). When time spent teaching science is compared to time spent teaching reading and math, it is easy to see that science has lost its importance. For grades K-3, the daily average for reading was 95 minutes, for math it was 41 minutes, and for science only 17 minutes. This same study for grades 4-6 showed the daily average for reading to be 66 minutes, for math 51 minutes and for science 28 minutes (Rowe, 1980). Elementary school children are interested in science, but by the tenth grade they

are either highly motivated in science by a source outside of school or they are no longer interested in scientific study (Rowe, 1980). The combination of these factors causes problem-solving skills to be reduced, leaving children entering middle school scientifically illiterate and with few if any critical thinking skills. If the time it takes to teach science is related to the science learned, and if this in turn is related to the child's ability to solve problems, then the result of decreased classroom time will be a decrease in test scores. Texas requires that middle school students take three years of math but only three semesters of science, allowing them a minimum of three semesters of electives. In high school, students are again faced with choosing electives. If they lacked a positive experience with science in elementary school, it has been found that the students take a minimum of science on the secondary level: 50% of high school students have completed their science requirements by tenth grade (Gerlovich and Downs, 1980). Another reason they elect not to take courses promoting critical-thinking skills is because the students lack a good scientific background (Yeotis and Hosticka, 1980). The result is that even though the United States economy is becoming more reliant upon technology, fewer students are interested in scientific careers (Gerlovich and Downs, 1980). This trend prompted an attempt to quantify the effect of reduced classroom time on science achievement; a pilot study was conducted during the 1981-82 school year.

Research Methods

A random sample of 200 eighth grade students served as subjects.

Half of these students were selected from a school district that provides for two semesters of earth science in the eighth grade (i.e. Population A). The other were selected from a school district where one semester of earth science is taught (i.e. Population B). All students were taken from regular classes, not from honors or basic classes. There was no apparent racial or economic imbalance between A and B.

Both school systems cover the same earth science topics in different time periods. Groups A and B were given an identical 75 question multiple choice examination (available upon request from the author) covering important topics in the eighth grade curriculum: plate tectonics, earthquakes, vulcanism, etc. As nearly as possible, testing conditions were identical for both groups.

Prior to testing, the students were given an explanation of the test. They were told that this test would not affect them academically. There was no apparent psychological risk associated with the test. Any student could refuse to take the test or at any time could choose to discontinue the experiment. After the explanation of the test had been given, instructions for taking the test were read aloud by the teacher. The same directions were also written on the first page of the test booklet for the students to read to themselves. Once all questions concerning the instructions were answered, the students began. There was a time limit of 45 minutes set for completion of the test. Although a time limit hampers the slower students, this serves to keep all students on task by allowing

a set amount of time to complete the achievement test.

The null hypothesis that children in Group A have the same average test score as children in Group B was tested using a t-test (Dixon and Massey, 1969,p.119).

Results and Discussion

Table 1 shows the results of the t-test. Since the observed t value (8.68) was greater than the critical t value (2.58) the null hypothesis was rejected. The result suggests that group A scored significantly higher than group B. This is a pilot study and other factors do affect the amount of science material learned. However, if the same test is given over a period of time to many other students, and the results remain significant, then it can be inferred that the amount of material learned is related to the time spent teaching science. Because this evaluation has not yet been repeated on other groups in different circumstances, the results should be considered as preliminary.

The goal of education is to produce citizens capable of responding to world and domestic affairs in a logical manner. People must be able to think, express themselves, use math and science, reason through problems, and apply technology, as well as show some understanding of other cultures. The public must be able to deal with unexpected changes, make value judgements, and be willing to continue learning throughout their lifetimes (A Statement by the Organizations for the Essentials of Education, 1981). Society provides few of the science education goals, therefore schools may be the only source of

this information (Harlen and Dahar, 1981). However, schools are not doing an adequate job because children are taking less science and math. Funds are not available to update textbooks, replace worn out equipment, and attract professional scientists to the teaching profession. As a result, scores on achievement tests are dropping. James Rutherford (1981) says that if the trend continues, it will cause national problems because our civilization is based largely on technology. It is evident that there is a necessity for current elementary and middle school students to be given the chance to acquire as much basic science knowledge as possible. The problem of a scientifically illiterate public, the lack of critical thinking skills, and the decline of reading ability, of test scores, and in number of professional scientists can be remedied to some degree by re-establishing science as a basic subject and providing more time in grades K-8 to teach this important subject.

Table 1. Statistical results from evaluating two groups of eighth grade earth science students.

Group	$\bar{X}$	S.D.	Range	t-value	df
A	52.05	9.415	86%-23%	8.68*	174
B	38.66	11.985	78%-17%		

*p<.05

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